DOCUMENT RESUME

ED 383 344 IR 017 199

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TITLE Design Considerations for Embedding Summary Writing Activities in CBI: Analysis of the Research.
PUB DATE 95
NOTE 12p.; In: Proceedings of the 1995 Annual National Convention of the Association for Educational Communications and Technology (AECT), (17th, Anaheim, CA, 1995); see IR 017 139.
PUB TYPE Information Analyses (070) -- Reports - Evaluative/Feasibility (142) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Computer Assisted Instruction; *Instructional Design; Learning Strategies; *Student Characteristics; *Writing Exercises; Writing Skills
IDENTIFIERS *Summarization

ABSTRACT

Summary writing is considered to be one of the power generative learning strategies. However, there is insufficient research to guide the design of summary writing activities in computer-based instruction (CBI). Examination of summary research suggests that variables such as learner characteristics, task condition, and presentation features influence the effectiveness of summary writing in promoting meaningful learning. This paper attempts to identify research issues as well as design guidelines for embedding summary writing activities in CBI in these three areas. Learner variables to consider in designing summary writing activities in CBI include prior knowledge, and age and metacognition. Task conditions include: availability of the lesson content while summarizing; frequency of summarizing; type of summary required; and presentation feature manipulations. Nine instructional design recommendations are made, focusing primarily on designing the summary writing activities to accommodate learner characteristics to reduce unnecessary demands on the learner while using summarization as a learning tool. It is proposed that further study examines the impact of highlighting information on the effectiveness of summary writing activities. Research in this area can provide insights into the mental processes of summarizing as well as useful guidelines for instructional designers in designing effective activities. (Contains 31 references.) (MAS)

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Title:

Design Considerations for Embedding Summary Writing Activities in CBI: Analysis of the Research

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Abstract

Summary writing is considered to be one of the power generative learning strategies. However, there is insufficient research to guide the design of summary writing activities in computer-based instruction. Examination of summary research suggests that variables such as learner characteristics, task condition and presentation features influence the effectiveness of summary writing in promoting meaningful learning. The paper attempts to identify research issues as well as design guidelines for embedding summary writing activities in computer-based instruction in these three areas.

How do instructional activities influence learning outcomes? According to cognitive theorists, there is a clear distinction between the role of the teacher and the role of the student in the learning process (Shuell,1988). The teacher's primary responsibility is to structure the learning activities in such a way that the students engage in the necessary information processing functions, and the student's responsibility is to carry out the functions. That is, instruction influences how students receive, process, and store information; it is then these student thought processes that directly mediate learning and achievement (Wittrock, 1986). For learning to occur, the critical functions of receiving, encoding, and retrieving must be performed by the student. Thus, researchers interested in improving the quality of instruction, including computer-based instruction, must focus on ways to help students engage in the critical thought processes that lead to effective learning. This paper will highlight research related to various issues of using summary writing as a learning strategy. The paper will also note potential research questions as well as instructional design recommendations based on the existing research.

Summary Writing

Summary writing is considered to be one of the power generative learning strategies (Pressley, Johnson, Symons, McGoldrick, & Kurita, 1989). Summaries are defined as condensed statements that represent the gist or essence of the information available (Johnson, 1983). Researchers propose a variety of descriptions of the processes involved in summary writing. Most of these descriptions include at least the operations of selection and reduction (Brown & Day,1983; Hidi & Anderson, 1986). Johnson (1983), for example, suggests that there are six components to the generation of a summary: (a) comprehending the individual propositions, (b) establishing connections between propositions, (c) identifying the constituent structure, (d) remembering the information, (e) selecting the information to be presented in the summary, and (f) formulating a concise and coherent verbal representation of that information.

Many researchers argue that the ability to summarize is important for understanding and remembering text. Kintsch and van Dijk (1978) suggest that readers form a gist which represents their overall comprehension of the text while reading text. According to these authors, the reading process involves multiple, cyclical processing of propositions to arrive at macrostructures of the discourse using macrorules and generation of a gist of the discourse based on the macropropositions in memory, control schema, and general knowledge. Under this conception, summarizing becomes an integral component of comprehension.

Summary writing has traditionally been used as a way to assess recall and comprehension (Head, Readence, & Buss, 1989). More recently, however, researchers have proposed that the processes involved in summarizing can facilitate learning since they help learners clarify the meaning and significance of the new information (Brown, Campione, & Day, 1981; Hidi & Anderson, 1986). This new look at summary writing is consistent with the generative learning view of summary writing as an effective method for constructing meaningful relationships during learning (Wittrock, 1990). Whether summarizing is truly an automatic by-product of reading or not, summary writing as a generative activity makes these mental processes conscious. This mindful activity makes it possible for teachers to assess students' comprehension of the text, for students to monitor their own comprehension, and for students' learning to become more meaningful and memorable.

Effects of Summary Writing on Learning

Although there are many empirical studies of summary writing, a majority of them focus on effects of various treatments on students' summary writing ability. Relatively few studies are available to examine the effects of summarizing on learning.

Wittrock and Alessandrini (1990) studied the generation of summaries and analogies in light of students' analytical and holistic abilities. Fifty-seven undergraduate students were randomly assigned one of

three treatments: read text, generate analogies, and generate summaries. All students read a 50-paragraph passage. For each of the fifty paragraphs, students were required to read and reread, generate an analogy, or generate a paraphrased summary. Analysis of student-generated analogies and summaries indicated that the two generation treatments induced the desired generative processing, and that summaries were somewhat easier to construct than analogies. Results on the posttest revealed that students in summary generation and in analogy generation groups learned significantly more than did students in the read only group. Analysis of time on task revealed that there was no significant difference in the amount of time spent learning the text.

Ross and Di Vesta (1976) studied the effects of oral summary activities on college students' retention. During the reading phase, 162 female undergraduate students independently read a passage and were given one of two kinds of learning instructions: students were told to read the passage or they were told prepare an oral summary from the reading. Pairs of students were then randomly assigned to one of three participation activities: present oral summary to partner, listen to oral summary of partner, or engage in neither activity during review. All students completed a multiple choice test and a delayed short-answer test . On measures of retention, results showed that the multiple-choice test scores for students who presented oral summaries and students who listened to oral summaries were significantly higher than those of students in the control condition. On the short-answer test, students who presented oral summaries performed significantly better than students who listened to summaries, who in turn performed significantly better than students in the control condition. Further analysis showed that the amount of time spent summarizing was highly correlated with summarizers' performance on both multiple choice and short answer measures. Overall, the authors concluded that subjects demonstrated a 25% advantage in retention after engaging in oral summaries, and a 13% advantage in retention after listening to partners' summaries over students who did not engage in any summary activity.

Design Considerations of Summary Writing Activities in CBI

Viewing summary writing as a generative activity requires that certain instructional design decisions be made regarding its effective use. In particular, learner characteristics, task conditions, and presentation features are expected to influence the effectiveness of summary writing activity in promoting meaningful learning.

Learner Variables

Research in aptitude-treatment interactions suggests that there are many learner characteristics that may influence the effectiveness of instructional strategies (Carrier & Jonassen, 1988). The most critical learner attribute in relation to generative learning activities is the learner's ability to carry out the mental processes required by the learning activity. Generative learning activities are more beneficial if students can engage in constructive mental processes without being distracted by the mechanics of generative task. Students' prior knowledge, age, and metacognitive potency are three learner characteristics that are closely related to their ability to benefit from summarizing (Jonassen, 1988).

Prior knowledge. Prior knowledge is perhaps the most relevant and strongest predicting factor in student learning (Kintsch, 1988; Tobias, 1987). Sufficient prior knowledge helps a reader arrive at the correct understanding of a text and reduces incorrect inferences. The perception of learning as a process of constructing meaningful relationships necessarily implies that learning must be built upon learners' existing knowledge. Sufficient prior knowledge is necessary for basic reading comprehension, for determining the relative importance of ideas, and for generating effective summaries.

Recht and Leslie (1988) investigated the effects of prior knowledge on short-term verbal and nonverbal memory and on long-term retention. Sixty-four junior high school students were classified as high or low reading ability and as possessing high or low level of prior knowledge about baseball. Each student read a story about a baseball game, used wooden figures to reenact the story, and verbally described the events. The student was then asked to summarize the story and sort random sentences into categories of high, medium, or low importance to the story. Results on the reenactment scores showed that memories of high knowledge students were significantly better than those of low knowledge students. Verbal retelling scores showed that high knowledge students recalled significantly more than low knowledge students. High knowledge students produced summaries that contained more correct information from the story, and were more like expert summaries than students with low knowledge. In addition, high knowledge students were more able to sort sentences into categories of high, medium, and low importance similar to those of experts than were low knowledge students. These results were similar for both high reading ability and low reading ability students.

In designing summarizing activities to enhance the quality of instruction, attention must be given to the available knowledge and experience levels of the learners. It is perhaps more beneficial to embed

summary activities in school tasks that are a part of continuous curriculum units since these curriculum activities often build upon prior learning of the same content area than in artificial learning tasks.

Age and metacognition. Age and metacognitive awareness are two related characteristics that influence students' ability to carry out the mental processes required by summary writing tasks. As students gain more experience in academic tasks, they are likely to gain skills in carrying out certain generative learning tasks, and they are also like to benefit from metacognitive experiences.

Garner (1985) investigated older students' ability to summarize text. One hundred and twenty ninth-grade, eleventh-grade and college students were asked to produce an optimal and a poor summary for a three-page general science article. Student summaries were scored on the number of important ideas included and succinctness. On the number of important ideas included in summaries, results showed that high school and college students were aware that important ideas from a descriptive passage should be included in a short summary of the passage. Seventy-three percent of all the students differentiated optimal and poor summaries by including more judged-important ideas in the optimal summaries, although college students showed higher awareness than high school students. College students were more capable of actually including important ideas in their optimal summaries than high school students. The author concludes that high school and college students are well awareness that important ideas should be included in summaries, and that this awareness is matched by an ability to actually include the important ideas in summaries in college students but not in high school students. On measures of succinctness, however, both high school and college students were significantly less aware and less capable.

Brown, Day, and Jones (1983) studied younger and older students' use of planning strategies in generating written summaries. Fifty-seven students in fifth-grade, seventh-grade, eleventh-grade and college learned two folk stories to criterion. The students were then asked to summarize one of the stories from memory three times: unrestricted, in 40 words, and in 20 words. Student summaries were rated on three measures: number of important ideas included, amount of verbatim information, and evidence of planning. On the number of important ideas included in summaries, seventh and eleventh-graders and college students exhibited similar patterns in including important idea units in their summaries, but college students showed greater efficiency at including more idea units in fewer words. Analyses of the unrestricted summaries and the 40-word summaries showed that seventh and eleventh grade students and college students did not differ in including important ideas in their summaries; all groups outperformed fifth-grade students. In the 20-word summaries, college students outperformed fifth, seventh, and eleventh grade students in including important idea units in their summaries. On amount of verbatim information, fifth and seventh graders produced more verbatim summaries while the majority of the eleventh graders and college students wrote summaries in their own words. On evidence of planning, young students tended to run out of space and could not include important ideas from the second half of the stories due to lack of planning. Overall, significantly more eleventh graders and college students exhibited spontaneous planning behaviors than did fifth and seventh graders.

It seems that without extensive strategy training, summarizing as a learning mechanism is more beneficial for older students than for younger students.

Task Conditions

The nature of the summary writing condition can be expected to mediate the quality of the summaries produced (Hidi & Anderson, 1986; Johnson, 1983). To the extent that these conditions influence the cognitive operations of the summarizer, they will influence the effects on learning outcomes. Four such conditions are 1) the availability of the lesson content during summarizing, 2) the frequency of summary activities within a lesson, 3) type of summary required, and 4) the presentation features of the lesson.

Availability of the lesson content while summarizing. Hidi and Anderson (1986) propose that if students are able to scan the material repeatedly during summarizing, the demands on the short-term memory are reduced, and there are more cognitive resources available for other operations such as making fine discriminations about the importance of ideas in the text, clarifying inconsistencies, and chunking larger text units. Therefore, the tasks of discrimination, comparison, inference, structure assembly, and writing can be performed more deliberately. More importantly, the summarizer can repeatedly check the production of the summary against the lesson content for accuracy.

On the other hand, when students must summarize from memory, these processes are given different priorities, assuming that students have not completely memorized the content first. The process of scanning is limited to retrieving available memory traces of the text. The tasks of discrimination, comparison, and inferencing are also more restrained to more important information because readers are more likely to remember important information than trivial information (Mandler & Johnson, 1977; van den Broek, 1988). Similarly, processes of reorganization and summary generation must rely heavily on

idiosyncratic schemata rather than on the text itself. When the propositions are recalled from memory to be summarized, they are more likely to appear in forms of personally relevant relationships than verbatim information from the original text. Students' mental operations can be expected to draw heavily on the relation between the new information and the learner's own experience and knowledge, and can be expected to strengthen and stabilize those relationships.

Empirical evidence that examines the variable of text availability is limited. Hidi (reported in Hidi & Anderson, 1986) reports ambiguous results comparing summarizing under text-present and text-absent conditions in two studies. In the first experiment, students were divided into two groups: text-present (summarize text while looking at text), and text-absent (summarize text from memory). Results showed that although the summaries produced in the two groups were similar, the text-absent condition led to higher recall scores than the text-present condition one week after the treatment. As expected, student summaries in the text-absent group were more likely to deviate from the original text and combine propositions. However, these results were not replicated in the second experiment.

Stein and Kirby (1992) studied the effects of text presence on students' summarizing and recall. Sixth-grade students summarized a passage under one of two conditions: text present or text absent. Students were then asked to provide oral free recalls of the passage. Student summaries were scored on amount of information included, the ratio of the number of important propositions over the total number of propositions in the summaries, and on the degree of non-verbatim integration of the ideas in the summaries. Student recalls were scored for amount of information included. Results were mixed. Specifically, the text-absent condition resulted in more integrative summaries for more able readers, but not for less able readers. Also, the amount of information included in summaries had a strong effect on recall, above reading ability, for the text-absent group. The text-present condition led to higher recall scores than did the text absent condition, regardless of reading ability levels. Reading ability and depth of integration in summaries, not number of propositions included in summaries, predicted recall performance in the text-present condition.

Tsai, Simsek, and Johnson (1993) studied the effects of text presence on students' summary production and comprehension during a computer-based tutorial. Fifty-two high school students enrolled in a math course studied a computer tutorial and were asked to produce three on-line summaries as they progressed in the lesson. The students were randomly assigned to one of four treatments: a) text-present underlining, b) text-present no underlining, c) text-absent underlining, and d) text-absent no underlining. In the two text-present conditions, students were allowed to review the lesson segment while attempting to summarize it. In the two text-absent conditions, students were informed that once they began writing summaries, they would not be able to review the lesson segment. In the two underlining conditions, students received the instruction with the important phrases underlined. In the two no-underlining conditions, important lesson information was not underlined. Student summaries were analyzed for number of words, number of important ideas, and number of extraneous ideas. Students completed an attitude survey and a short-answer post-test. Results showed that underlining important information for the students led to significantly longer study time and significantly higher post-test scores than the no-underlining conditions. However, being able to review the lesson while summarizing it did not help students produce significantly better summaries and did not lead to significantly higher post-test scores than students in the text-absent conditions.

Tsai (1994) examined the effect of lesson availability in a similar study. High school students studying complex computer-based biology lessons were randomly assigned to several summary-reading and summary-writing treatments. Students who were assigned to "summary writing from memory" conditions studied the lessons one section at a time, and when they indicated that they were ready to summarize the section, they were not allowed to review the section's content while they wrote the summary using paper-pencil work sheets. Students who were assigned to "summary writing with review" also studied the lessons one section at a time. When they indicated that they were ready to summarize each section, they were given the choice of reviewing the content while writing the summary using paper and pencil work sheets. The students' summaries were scored for number of words produced, and the number of independent clauses produced that matched expert summaries. Students also completed a multiple-choice test, a short-answer test, and an attitude survey. Results showed that students who were given access to the lesson while summarizing it produced longer summaries and included more ideas that matched expert summaries. Correlation analysis showed that summary length and number of matching ideas in the summaries were highly correlated to students' performance on the achievement tests. However, the treatment did not directly affect achievement, attitude or learning time.

Research in a related areas such as adjunct questioning and inference verification also provides ambiguous results. Hayes-Roth and Walker (1979) studied the effects of text availability on students' ability to verify inferences. Eight undergraduate students studied four pairs of text passages under two

conditions. In the text condition, students read the passages before completing an inference verification test. They were encouraged to review portions of the texts while trying to judge whether the inferences were true or false. In the memory condition, students were asked to read the passages very carefully, and were asked to complete adjunct questions on arbitrary information in the texts to maximize learning from the texts. They were then asked to complete the inference verification test without referring back to the texts. All students were asked to justify their reasoning for their answers while completing the inference test. Performance on the inference verification test showed no significant difference between the text and memory conditions. However, on the accuracy of students' justification of true inferences showed that the proportion of correctly justified true inferences was significantly higher in the memory condition than in the text condition. Further analyses of students' verbal protocols indicated that students in the memory condition were more able to identify the critical facts underlying true inferences than students in the text condition.

In conclusion, there is sufficient evidence to suggest that access to text during summarizing mediates the quality of the summaries. However, there is limited evidence about how this influences the quality of learning. Theoretical speculation and the limited research evidence suggest that summarizing from memory may facilitate long-term retention of the lesson content. A concern not addressed in the existing research is how students actually use the opportunity to review text as they summarize. In a computer-based learning environment, this information can be tracked, and it may provide additional insight to how availability of lesson content can mediate summarizing and learning.

Frequency of summarizing. Frequency of summarizing refers to the number of noncumulative summaries required for a given amount of lesson content. It is related to the amount of information to be summarized in each summary. Current understanding of the spatial and temporal limitations of the short-term memory suggests that longer segments are more difficult to summarize than shorter ones. Hidi and Anderson (1986) suggest that shorter segments are likely to contain fewer ideas and ideas which are closely related, and place relatively less processing demands on students' short-term memory during summarizing than long segments. Exactly how this variable affects learning, however, is unclear.

Spurlin, Dansereau, O'Donnell, and Brooks (1988) had 48 undergraduate students summarize a passage. Students were randomly assigned to one of three conditions: produce frequent noncumulative summaries at equally spaced intervals throughout the passage, produce infrequent summaries, or simply read the passage. All students completed a delayed test requiring them to write a well-organized essay reflecting what they had read five days after the treatment. The essays were measured on amount of recall and overall organization. Analyses of student summaries showed that students in the frequent summarizing group wrote more complete summaries than students in the infrequent summarizing group. However, on both amount of recall and overall organization of the post-reading essay test, only the infrequent summarizing group significantly outperformed the control group.

Germane (1921) studied the effects of written paragraph summaries on students' learning of science texts. Nine hundred sixth-, seventh-, and eighth-grade students were randomly assigned to summarizing group or re-reading group while studying two science articles. Students in the summarizing group were first taught how to summarize two sample paragraphs. Then for each article, students were asked to read carefully and summarize each paragraph. A specific time restriction was enforced. Students in the re-reading group were asked to read the article as many times as they could within the same time limit. Immediate and delayed free recall tests were given. Results showed that the re-reading group performed significantly better on both the immediate and the delayed recall tests. These results held true for questions that addressed main ideas and minor ideas in the articles. The author speculated that the summarizing group was handicapped by the method of summarizing each paragraph since the students seemed to have a large number of isolated facts but failed to see the relationship and grasp the article in its entirety.

Tsai (1994) in the study mentioned earlier, randomly assigned high school students to Frequent or Infrequent summary activities while they studied complex biology lessons using computer-based lessons. Students who were assigned to the Frequent treatments were required to read or write summaries for each content topic of the lessons. These students wrote a total of 12 summaries while studying two lessons. Students who were assigned to the Infrequent treatments were required to read or write summaries for each major content unit of the lessons. These students wrote a total of 4 summaries while studying the two lessons. Results showed that students who participated in frequent summary-writing activities wrote significantly more words in total than students who participated in infrequent summary-writing activities. Again, summary length was highly correlated with performance on achievement tests even though the treatment itself did not directly lead to significant differences in achievement or time.

There are three reasons that summarizing relatively longer lesson segments may have positive effects on learning and retention. First, students who summarize infrequently are expected to extend more recall effort than do students in frequent summarizing group, and the increased effort may lead to more

effective delayed recall. Second, students are more likely to encode and retrieve meanings and relationships than isolated facts. When students summarize large chunks of content, they must identify the relationships among various concepts in the lesson whereas summarizing short segments of content may force them to focus on isolated concepts. Third, the mechanics of frequent activities may distract learners' attention from the content of the lesson. When students are only required to summarize infrequently, they are more likely to adopt text studying, not summarizing, as the primary task.

In conclusion, the frequency of summarizing within a lesson is expected to mediate summary production and learning. Limited empirical evidence suggests that the shorter a lesson segment the easier it is to summarize. However, there is also reason to speculate that summarizing longer lesson segments may be more beneficial for learning. Clearly this issue needs further examination.

Type of summary reuqired. Researchers have utilized a variety of types of summaries to facilitate learning. Taylor and Beach (1984), for example, taught students to recognize and use the existing textual structure to guide their summary production. Wittrock and Alessandrini (1990) and Tsai (1994) required students to summarize "in their own words." Brown, Day, and Jones (1983) required students to first learn the text "to criterion," and then to produce summaries according to various length constraints. In the Ross and Di Vesta (1976) study and the Recht and Leslie (1988) study mentioned earlier, students were required to produce oral summaries of the material.

Hidi and Anderson (1986) proposed that there is a difference between producing a "reader-based" summary and producing a "writer-based" summary. Reader-based summaries place significant emphasis on proper planning (Brown, Day, & Jones, 1983) as well as effective grammar and prose structure skills. The purpose of the reader-based summaries is to present an effective communication of the orginal material to others. Writer-based summaries, on the other hand, primarily serves the producers of the summaries to help them condense the information for their own use. Writer-based summaries place much less emphasis on the structure of the writing, and more emphasis on the usefulness of the content for the summary writers. Hidi and Anderson (1986) thus suggest that writer-based summary writing is more efficient as a learning strategy than reader-based summary writing. Although this proposition seems logical, there is little empirical evidence so far to demonstrate the relative learning value of these two types of summaries.

Presentation Feature Manipulations. Presenting stimuli with distinctive features has long been a prescribed strategy for instructional designers to help students focus attention on important information (Gagne, Briggs, & Wager, 1988; Wager & Gagne, 1988). This prescription is driven by the understanding that students have limited short-term memory capacity, and instructional events must take advantage of selective perception. The underlining strategy is widely used to highlight information for students who may not be sensitive to its importance. It is an effective tool to cue the students' attention which in turn results in better retention of that information.

Philosophically agreeable or not, successful students are often those who are able to recognize as important the ideas that their teachers also consider important. Many researchers believe that students fail to grasp the important information while studying. This is often cited as a major obstacle to successful use of effective learning strategies (Anderson & Armbruster, 1984; Winograd & Bridge, 1986). It may be necessary to direct students' attention to important information so that they benefit from generative learning strategies more efficiently.

In the Tsai, Simsek and Johnson study cited earlier (1993), students who studied the computer-based tutorial with important information underlined tended to include more important ideas than students who were not aided by the underlining, although the differences were not significant. However, the underlining treatments led to significantly higher post-test scores.

Garner and McCaleb (1985) studied the effects of cueing, organization, and reduction constraints on undergraduate students' summary production. The cueing variable included 3 treatments: a) no cueing, b) explicit topic sentences, and c) signal words such as "important" embedded in the topic sentences. Two levels of organization were used: a) all important ideas were presented together, and b) important ideas were distributed among the paragraphs. Two levels of reduction constraints were studied: a) three-sentence summary, and b) seven-sentence summary. Students read a seven-paragraph science text in one of the treatments and wrote summaries. Student summaries were scored for number of words, number of important ideas, evidence of deviation in order of information, and evidence of integration. Results suggested that cueing had a significant effect on summary scores. Specifically, both cueing treatments led to significantly higher number of important ideas in student summaries than no cueing, with no significant difference between the two cueing conditions. Also, both cueing treatments produced significantly more integration of ideas in student summaries than no cueing, again with no significant difference between the two cueing groups.

It is arguable that the very strategy of highlighting important information may interfere with students' construction of personally relevant relationships out of the instructional information. The processes of integrating the information and selecting important ideas may be reduced to a more mechanical process of locating cued phrases in the text. Nevertheless, the results hold significant promises for the instructional designer. It seems possible that simple manipulations of text features can significantly increase the effective use of complex learning strategies such as summarization. The reality of educational practices is that students are often evaluated against what instructional designers, teachers, and other experts believe to be important. Thus, a pragmatic task of designing instruction is to engage students in effective generative activities in order to learn what is considered important. To this end, simple attention focusing strategies such as underlining important phrases may enhance the learning outcome of summary writing activities.

Instructional Design recommendations

Several instructional design guidelines can be drawn from the research evidence in this area. These recommendations focus primarily on designing the summary writing activities to accommodate learner characteristics to reduce unnecessary demands on the learner while using summarization as a learning tool.

1) Summary writing strategy can generally be reliably used with students who are older, have more sophisticated metacognitive control, or possess high levels of prior knowledg.

2) The teacher or instructional designer may first test to make sure that students are able to perform the mechanics required by the summary writing task with relative ease.

3) Highlight important information for students to guide their summaries, especially for complex content, and for students with low prior knowledge or low language who are less able to differentiate between important and not-important information

4) For learners with limited experience writing summaries, provide structure in the summary writing activities to make this a productive learning tool. Provide structure and prompts (such as "look for the topic sentence, look for the support idea, do not include repetitive examples..."). Encourage students to provide oral summaries if writing is a significant challenge for them.

5) Use summary writing activities for curriculum topics that build upon each other so that students can draw on their knowledge of previous topics to write effective summaries.

6) Encourage "writer-based summaries" to reduce the demand on writing skills, and to promote summary-writing as a learning tool. Encourage students to make their summaries personally meaningful. As Stein and Kirby (1992) found, depth of integration in students' summaries may be an important predictor of depth of learning.

7) Avoid using length constraints. Length constaints tend to require careful planning and editing which may distract from learning of the content.

8) Allow students to review the lesson while summarizing it. To make this a useful option, encourage students to check the accuracy of their summaries during such reviews. Also, help students develop the strategy of monitoring their comprehension through such reviews.

9) Allow for frequent summary writing activities (Tsai, 1994), but avoid making summary writing the predominant task which may distract from learning (Germane, 1921).

Further Research Issues

Based on the above findings, several research issues are worth exploring.

1) It is clear that learner characteristics have a strong impact on the effective use of summary writing strategy in learning. It would be helpful for the instructional designer to have a clearer set of algorithm in selecting the key learner characteristics to be studied and designing the most appropriate summary activities. Work in mathemagenic and generative learning strategies by researchers such as Pat Smith promises to provide some clarification in this area.

2) What is the best way to predict the appropriate frequency of summary writing activities? It seems that learner characteristics, complexity of materials, and desired learning outcome are important considerations. But the guidelines for making such determination should be derived from empirical evidence.

3) The variable of availability of lesson during summarization needs further study. There are at least three questions regarding this variable. First, what kind of summaries tend to be produced? There is contradicting evidence so far on the effects of this variable on summary production. One of the proposed outcome of summarizing from memory is that students integrate more information into their personal schemata than if if they simply copy the information from the original lesson.

Second question: what is the impact on different kinds of learning? It has been hypothsized that students who summarize from memory will produce more integrated summaries, and will demonstrate a

higher level of increase in their capability to analyze and synthesize the information than students who scanned the lesson frequently during summarization. Clarification from empirical evidence in this area will guide the instructional designer in determining the appropriate strategies.

Third question: what strategies do students use to write summaries? Tsai (1994) suggested summarizing from memory is an unfamiliar task for many students, and that they must learn the strategy of studying the lesson more carefully before beginning their summary writing. In addition, Tsai (1994) suggested that when students do have the option of reviewing the lesson while summarizing it, it is unclear how they actually use that option. If they do not review the lesson to increase the accuracy of their summaries, then this option is not necessary. Thus, examination of student behaviors under different conditions of this variable will be helpful in designing the appropriate summary activities.

4) The effects of writer-based and reader-based summaries should be examined. Hidi and Anderson (1986) would propose that for learning purposes writer-based summaries are more efficient and preferrable to reader-based summaries. It could be argued, however, that the process of planning and structuring a "good" reader-based summary is highly beneficial to learning, especially for people who believe that "the best way to learn a topic is to teach it." Thus the question of "is writer-based summary writing more efficient and beneficial" should be studied. Related to this question is the need to examine whether summary length constraints enhance or reduce efficiency of learning for the strategy of summary writing.

Conclusion

Embedding generative learning activities in CBI courseware has been recommended for promoting deep processing in CBI (Jonassen, 1988). However, it is important that instructional design decisions for these activities are informed by sound theoretical and empirical evidence. This paper focused on one of the more powerful generative learning activities, namely, summary writing. It reviewed current understanding of the mental processes involved in generating summaries, and examined instructional design variables that are believed to mediate summary production and its effects on learning.

The mental processes involved in producing summaries -- such processes as scanning information, comparing information for importance, and reorganizing the important information into a coherent format -- promote deep processing. These processes also provide an opportunity to strengthen the conceptual relationships that the learner may have subconsciously constructed during learning. There is convincing evidence that summary writing activities can facilitate student learning. However, many instructional design decisions regarding the effective use of summarizing have not been resolved. Specifically, limited evidence is available to determine whether it is more beneficial to require students to summarize from memory than to summarize while reviewing the lesson content. It is unclear how the frequency of summary activities within a given lesson affects summary production and its effects on learning. In addition, we need to further study the impact of highlighting information on the effectiveness of summary writing activities. Research in these areas can provide insights into the mental processes of summarizing as well as useful guidelines for instructional designers in designing effective summarizing activities.

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